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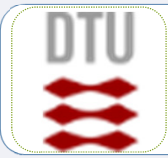
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# Impact on wind turbine loads from different down regulation control strategies

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## Abstract

Three characteristic derating strategies on the upstream wind Turbine are studied and the load impact to the downstream one is assessed. These are defined as minimum/maximum rotor speeds (minRS, maxRS) and minimum thrust (minT) modes. Derating factors of 20% and 40% on available power are applied together with 4 and 7 diameters WT interspace. The study is based on aeroelastic simulations of a 2MW generic WT model including wake effects. The results show that below rated wind speed (8m/s) the downstream WT blade flap fatigue loads are minimized when the upfront WT is derated with the minRS strategy. The maxRS mode returns always the highest loads. When the WTS are aligned with the wind direction (full wake situation) the load levels for minRS and minT strategies are almost equal. Above rated wind speed (16m/s) the tendency is the same as at 8m/s. Finally, the fore-aft fatigue loads on the tower base and the main bearing yaw moment follow the same trends as the blade for both below and above rated wind speed.

## Objective

Power down regulation can be done in different ways by adjusting the rotor speed and blade pitch angle on the individual turbines, which affect the fatigue loads on the turbine components. Until now the main focus was on power optimization [7, 8] and there has been limited documentation on the load variations as a result of different down-regulation strategies on wind turbines under wakes.

Main objective: Load impact for three characteristic derating strategies on the upstream WT to the downstream one

## Method

### High fidelity aeroelastic simulations

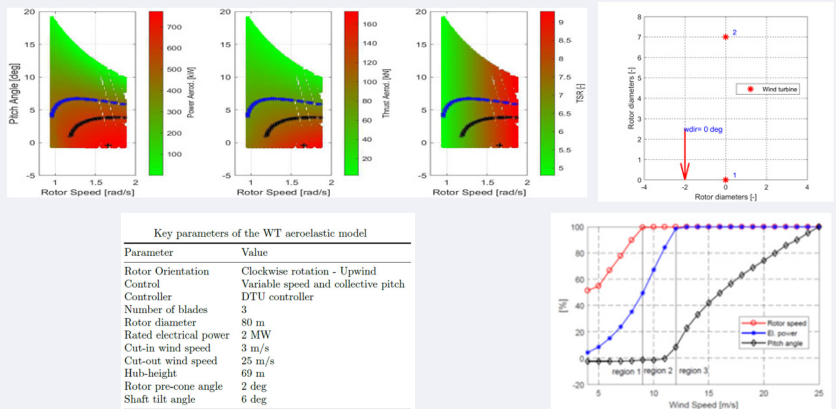
- HAWC2 - Including the Dynamic Wake Meander model (DWM) [3, 4, 5]
- Generic 2MW Wind Turbine (WT)
- Two WTs in wind farm configuration
- Upfront WT-2 is down-regulated, downstream WT-1 normal operation

### Wind farm derating control strategies

- minimum/maximum rotor speeds (minRS, maxRS)
- Minimum thrust (minT)

### Cases

- Down regulation by 20% and 40% on available power
- WT interspaces of 4 and 7 Diameters (D)
- Ambient wind speed and direction: 8m/s, 16m/s and  $\pm 15$  degrees



## Results

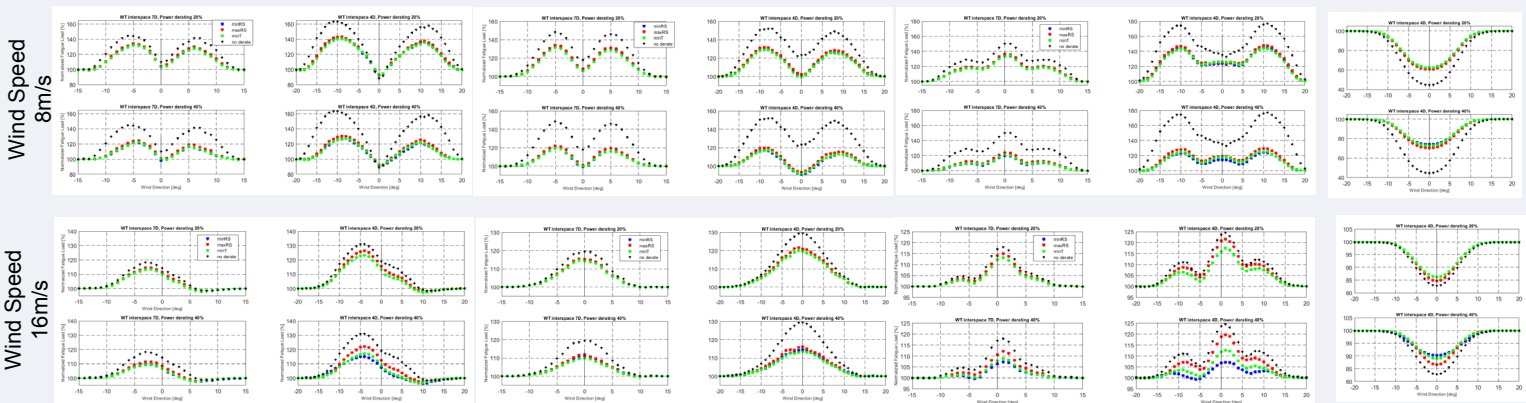
### Equivalent fatigue loads on downstream WT-1

Blade root flapwise BM

Tower base fore-aft BM

Main bearing yaw moment

Wind speed (4D)



## Conclusions

- Below rated wind speed (8m/s) the downstream WT blade flap loads are minimized when the upfront WT is derated with the minRS and minT strategy
- The maxRS mode returns always the highest loads variations
- The load levels for minRS and minT strategies are almost equal when the WTS are aligned with the wind direction (full wake situation)
- Above rated wind speed (16m/s) the tendency is the same as at 8m/s
- Control strategies are directly linked with the deficit strength of the upstream turbine operation.

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